Space Weather Technical Forecast

Issued on Saturday, 02 April 2022 at 01:29 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: M-flares likely (R1/R2 Radio Blackouts), with a slight chance X-flares (R3 Radio Blackouts). G1-G2 Minor to Moderate Geomagnetic storms possible, mainly day 1 (2nd) from CME and fast wind arrivals.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was Low with a number of C-flares observed. There are seven sunspots on the Earth-facing disc, including recently Active AR2975 Eac/Beta. While this has shown some signs of simplification, this is now approaching the west limb resulting in some difficulty to assess and maintains sufficient flux for further M-class or X-class flares. Nearby AR2976 Eho/Beta-Gamma has shown some growth around its leader, with an opposite polarity spot developing, whilst a new region developed between these two spots. In the southeast AR2978 Ehi/Beta-Gamma saw notable growth in intermediate spots, whilst AR2981 Dai/Beta-gamma delta, maintained its small delta spot region. The other two regions remained small and simple There are number of filaments on the disc, however these have remained stable. No Earth-directed CMEs were observed in the last 24 hours, whilst the CME from the M9.6 flare of AR2975 on 31st was assessed as missing.

Solar Wind / Geomagnetic Activity: The solar wind environment was dominated by the easing influence of the recent CME arrivals, although a notable discontinuity occurred around 01/1230 UTC, likely a sector boundary crossing as Earth moved out of the passing flux rope. Solar winds speeds remained slightly elevated at 450-500km/s, while the density was below average for much of the period, but briefly rose to above average after this discontinuity. The total interplanetary magnetic field (IMF) Bt, eased from strong levels at 23nT, to moderate levels at 8nT by the end of the period. The north-south, Bz, component rotated from strong positive/northward (15nT) at first, to moderate negative/southward (-9nT) at 01/0930 UTC, then back to neutral by 01/1230 UTC. Thereafter, this persisted at weakly, mainly negative values, between 0nT and -5nT. The phi angle was mainly positive (away from the Sun) until just after 01/1200UTC, when it became mainly negative (towards the Sun). Geomagnetic activity was Unsettled to Active at first (Kp3-4), but eased to mainly Quiet (Kp2) from 01/1500 UTC.

Energetic Particles / Solar Radiation: The high energy proton flux (10MeV) measured at GOES-16 has been easing towards background levels, staying below the S1-level. The high energy (greater than 2MeV) electron flux as observed by GOES-16 at GEO was at Normal Background levels. The observed fluence at 01/0000 UTC was 1.65e6 integrated pfu, with an initial decline followed by a level trend.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is likely to become Moderate each day, with a slight chance of becoming High, primarily due to the recently active AR2975 but also the other large active regions on the disc. This risk reduces later in the period as AR2975 and AR2976 rotate away, over the west limb.

Solar Wind / Geomagnetic Activity: There is one potentially Earth-directed CME, from the X1.4 flare on the 30th. Whilst this is low confidence, with some potential for the CME to miss or only give a glancing impact, arrival is currently expected 02/1400+/- 10hrs. Coronal hole fast wind

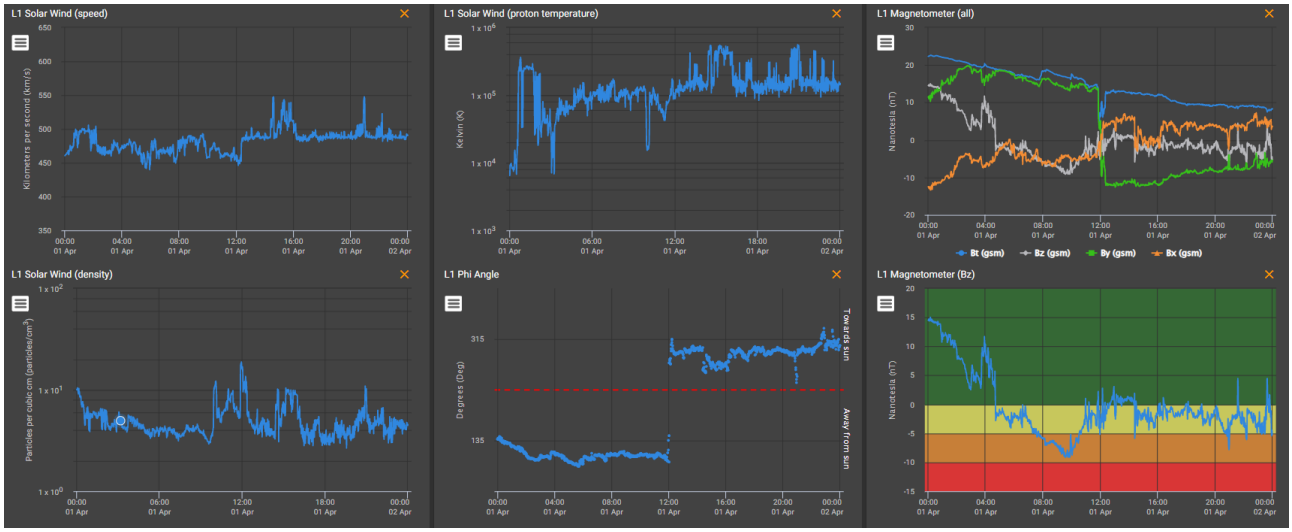
Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

arrival is also expected day 1 (2nd), and could perhaps combine with the CME arrival. Ongoing CME and fast wind effects will then gradually wane day 2 and early day 3 (3rd and 4th), with solar winds easing back to background day later in the period. Geomagnetic activity will initially be Quiet to Active, but easing, before a chance of G1/G2 Minor to Moderate storms with both CME arrival, and CH fast wind enhancements day 1 (2nd). These have an ongoing potential through day 2 (3rd) before a return to mainly Quiet to Unsettled conditions is then expected day 3 and 4 (4th and 5th)

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) is expected to remain at background levels, but with a slight chance of rising above the S1 level, primarily from any further flare activity of AR2975, but also with any activity that develops from the other active regions on the disc. This risk reduces as AR2975 rotates over the west limb later in the period. The high energy electron flux (greater than 2 MeV) is forecast to be at background at first, but likely reaching High diurnally later in the period, once the CME and any initial solar wind enhancement from the arrival of the fast wind of CH70 and 71 subside. This will bring a chance of Active 24 hour fluence (greater than 1e8 integrated pfu) mainly day 3 onward (4th).

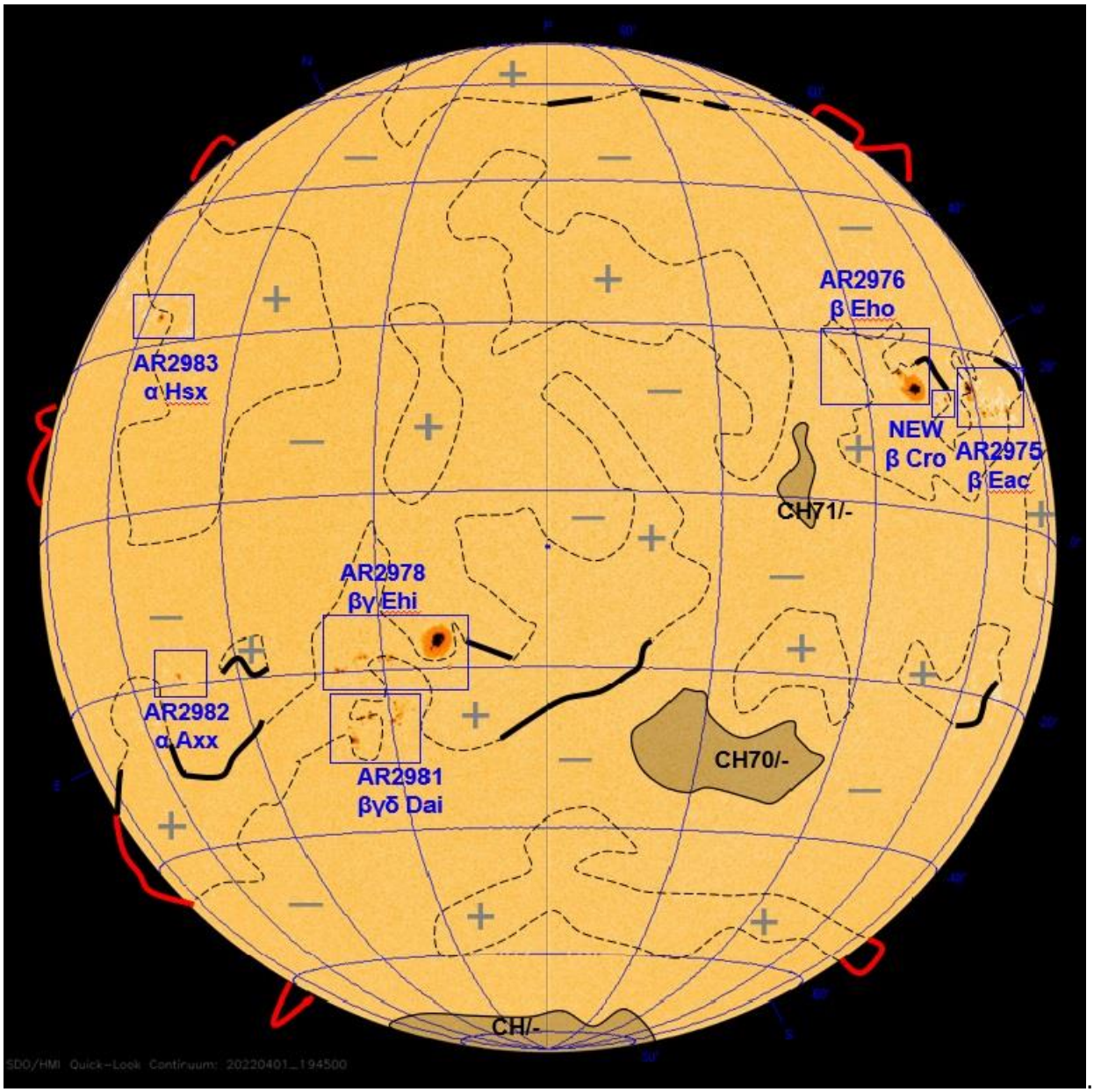
Figure 1: Observed Solar winds



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Figure 2. Solar Analysis Valid 01/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Geomagnetic Storms:

The solar wind environment around Earth is still recovering from recent CME arrival, with solar winds currently slightly elevated, along with spells of southward pointing IMF (Interplanetary Magnetic Field). A further potential enhancement is expected later on day 1 (2nd) due to the arrival of the CME which left the Sun on the 30th, due to an X1.4 flare. Whilst confidence is low regarding the extent and strength of the arrival, this is currently forecast to arrive at 02/1400 UTC +/- 10hrs. No other CMEs have been assessed to be Earth-directed.

A further enhancement is also possible from the fast winds of CH70/- and CH71/-, which due to their location would be expected to arrive through day 1 (2nd). However, there is little sign of fast wind on STEREO A, and neither of these regions align with observed fast wind conditions on the previous rotation, leading to significant uncertainty regarding the strength of any enhancement that might occur.

Geomagnetic activity is expected to be Quiet to Active at first, as recent CME influences continue to recede. There is chance of G1/G2 Minor to Moderate storms with both CME arrival, and CH fast wind enhancements day 1 (2nd), with an ongoing potential through day 2 (3rd). Should these arrive together, with a notable southward pointing IMF, G3/Strong Geomagnetic storms cannot be completely ruled out. A return to Quiet to Unsettled conditions is then expected day 3 and 4 (4th and 5th).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	70	40	5	1
Strong	G3	No	5	5	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

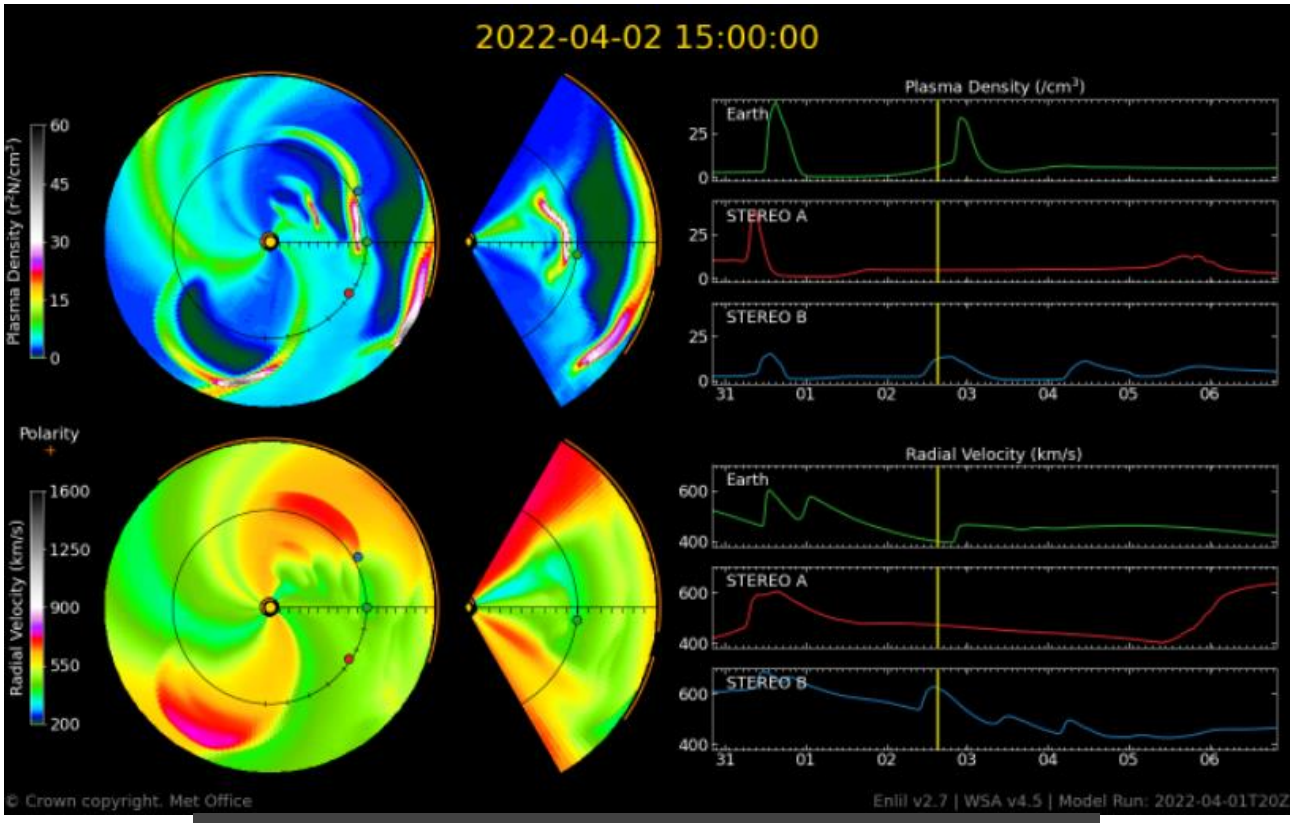
Geomagnetic Activity - Earthbound Coronal Mass Ejections

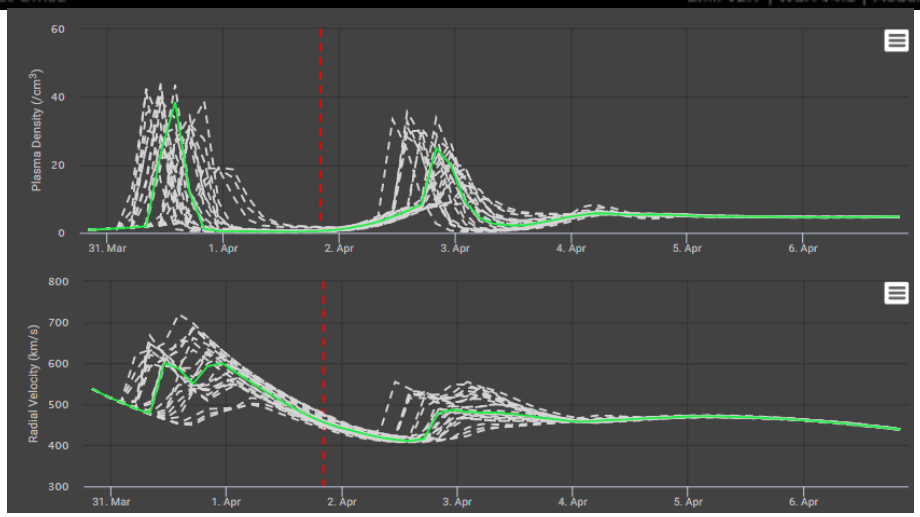
Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
30/1738	Partial	X1.4 flare	AR2975 N05W40	700 km/s	02/1400 UTC +/- 10hrs	Low confidence. Possible glance impact

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Figure 3: Enlil Forecast – Slightly later arrival in enlil, but low confidence in CH fast wind in model. Expected arrival slightly earlier.





Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Radio Blackouts - X-Ray Flares:

Solar activity has been Low in the past 24 hours, with numerous C-flares, with seven sunspot regions on the visible disc.

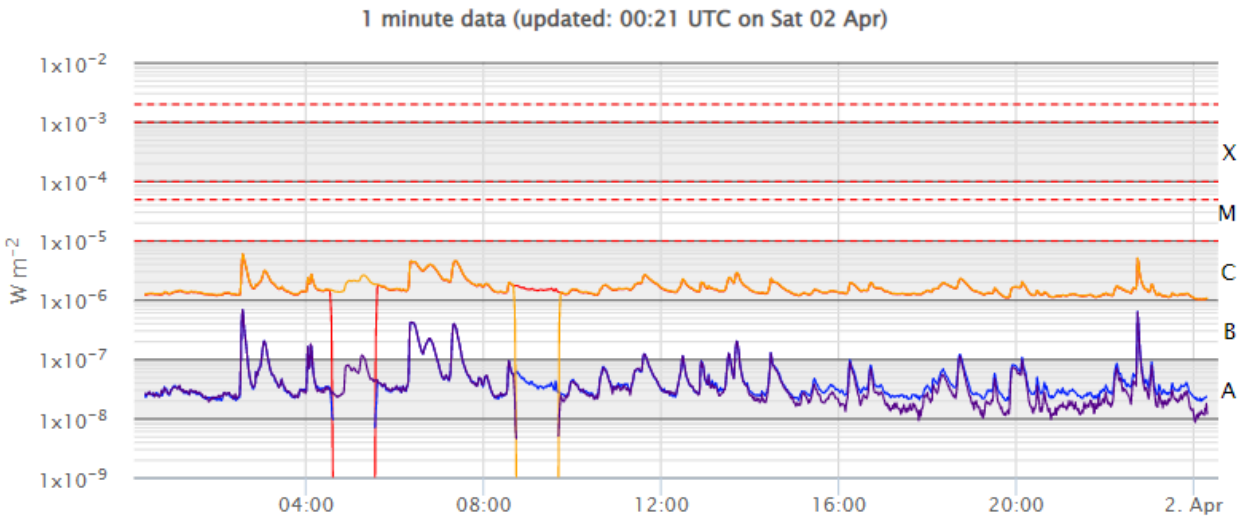
The most active has been AR2975 Eac/Beta, which has been the source of both an X1.4 (on 30th) and M9.6 (on 31st), as well as previous M-flares. This is now approaching the west limb, and becoming harder to assess, although signs are of some slight simplification with a reduction of visible penumbral area. This however, could be a product of its viewing angle. Nearby sunspot AR2976 Eho/Beta-Gamma has shown some increased complexity, with the development of an umbra within a positive penumbral area near its large leader spot, however remains relatively inactive. Both of these spots may be destabalised further by the development of a small, currently unnumbered Cro/Beta region between them, and are the main source of higher M-flare and X-flare potential.

In the southeast disc AR2978 .Ehi/Beta-gamma has shown further development within its intermediate spot area, whilst to the south of this region AR291 Dai/Beta-delta appears to have stalled with growth, but maintains a small delta-spot region amongst its intermediate spots. Both these regions are potential sources of M-flares.

Overall solar activity is likely to become Moderate each day, with a slight chance of becoming High. This risk reduces later in the period as AR2975 and AR2976 rotate away, over the west limb.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	70	70	60	50
Very Active	R3 to R5 X Class	No	15	10	5	5

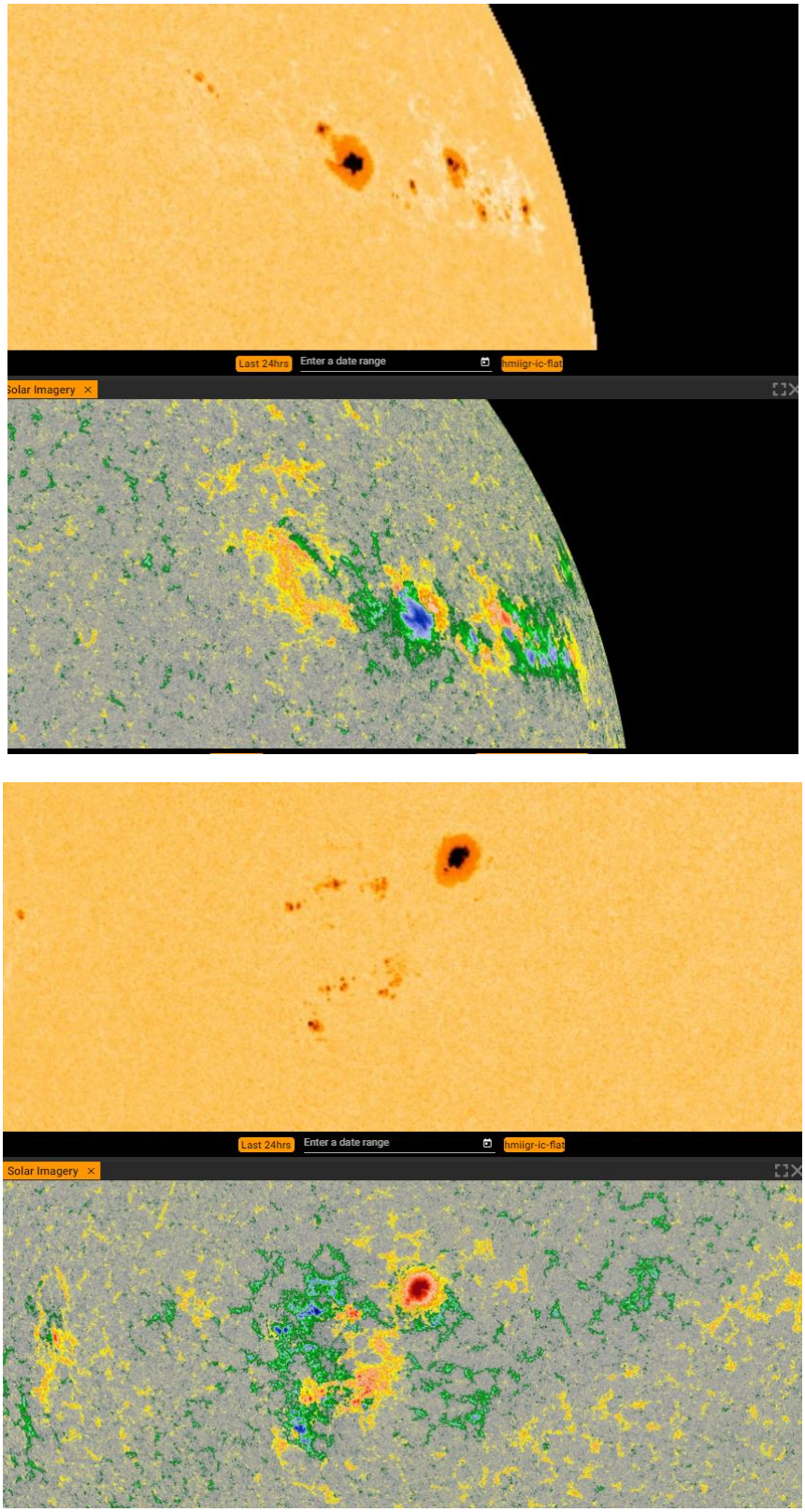
Figure 4: GOES 16/17 X-ray Flux:



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Figure 5: SDO Intensitygram and Magnetogram of both major sunspot region (AR2975/AR2976 top and AR2978 and AR2981 bottom)



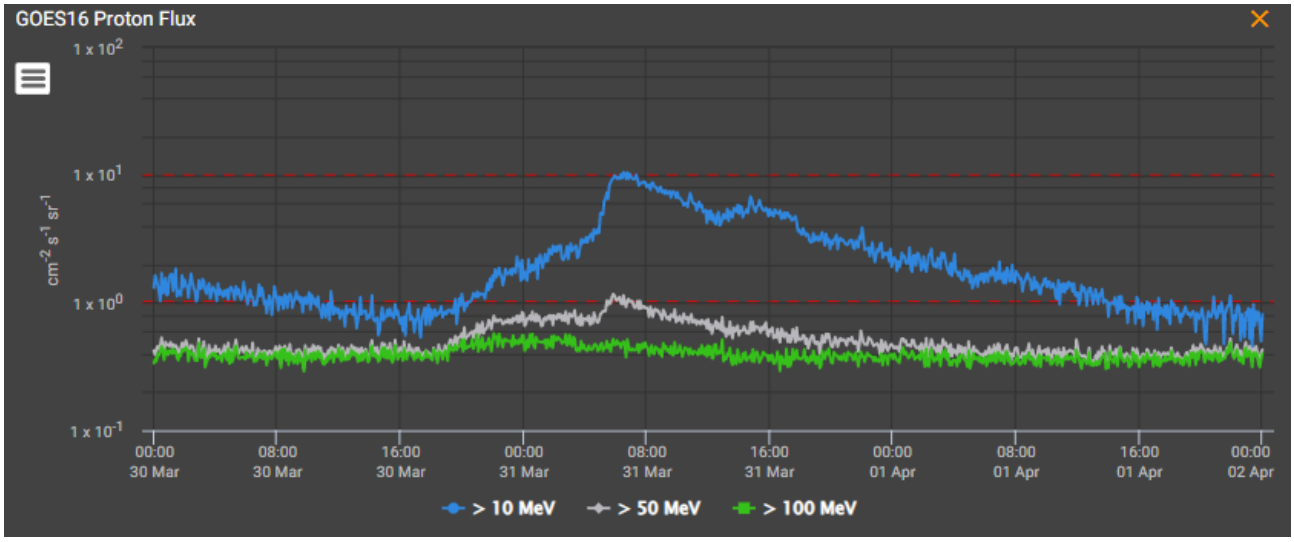
© Crown Copyright 2022. All Rights Reserved.

Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (10MeV) measured at GOES-16 has been falling back to background during the last 24 hours. AR2975, approaching the northwest limb, has produced proton rich flares and continues to have the potential for M and perhaps low X-flares. Furthermore, there are a number of other potential flare sources on the disc including AR2976 closely following AR2975, and also AR2978 and AR2981 in the southeast disc, the former having shown some development through the last 24 hours whilst the later has a small, but evident delta spot. Overall, this maintains a daily slight chance of the proton flux rising to the S1 level, although this reducing day 4 (5th), as AR2975 will have rotated beyond the west limb on the previous day.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	10	10	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 6: GOES-16 Proton Flux over the last 3 days.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

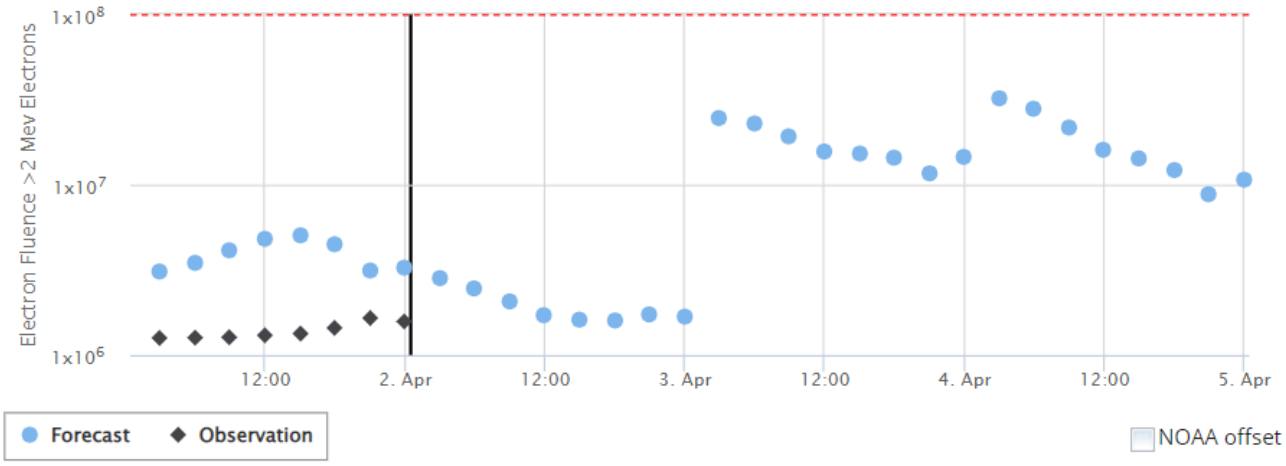
High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2 MeV) flux, as observed by GOES-16 at GEO is expected to be largely background levels day 1, (2nd) with the potential for geomagnetic enhancement from arriving fast winds of CH70 and CH71, along with the expected arrival of the CME from the X-flare that occurred on the 30th. Flux levels then have the potential to rise later in the period as the near Earth solar wind environment eases, most likely through day 3 and 4 (4th and 5th). This will bring a chance of diurnal spells of High flux, perhaps persistently High by the end of the period.

The associated 24 hour fluence will remain below the Active (1e8 integrated pfu) level day 1 (2nd), but has an increasing chance of rising above thereafter. REFM gives a good guide to the next 24 hours, in the absence of any CME or fast wind arrival. However, its value will be much reduced beyond this period, and once any CME or fast wind does arrive.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	10	30	30
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	5	5

Figure 7: GOES-16 Electron Fluence with REFM



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.